A. K. PANDEY*: Development of seed and fruit in *Tithonia diversifolia* (Hemsley) A. Gray (Asteraceae)

A. K. パンデイ*: ニトベギクの種子と果実の形成

Genus *Tithonia* (tribe Heliantheae, Asteraceae) includes 10 species which are mostly distributed in Mexico and Central America but some species are also naturalised in the Old World (Mabberley 1987). Studies on reproductive biology of *Tithonia* are confined to embryological investigations carried out in *Tithonia rotundifolia* (Pullaiah 1978) and *T. diversifolia* (Lakshmi & Pullaiah 1987). As developmental anatomy of seed and fruit has not been studied in *T. diversifolia*, present paper describes these aspects in this taxon of ornamental value.

Materials and methods Materials collected from the plants growing in the Botanical Garden of Bhagalpur University, were fixed in formalin-acetic-alcohol and stored in 70% ethanol. Customary methods of dehydration in TBA series and embedding in paraffin wax were followed. Microtome sections between 8–15 micron thickness were stained in safranin fastgreen combination.

Observations Ovary and ovule. The syncarpous and unilocular ovary contains a single anatropous, unitegmic and tenuinucellate ovule (Fig. 1A). The vascular supply of the ovule passes the funicle and ends on the antiraphe side at the level of endothelium (Fig. 1A).

Integument. At the organised female gametophyte stage, the integument is 17–20 cell-layers thick at the level of the embryo sac (Fig. 1L), and its inner epidermis differentiates as an endothelium. A few cell-layers of the integument around the endothelium show depletion of their contents and differentiate into a periendothelial zone (Fig. 1A, B). Rest of the cells of the integument outside this periendothelial zone do not show any characteristic feature. The outer epidermal cells of the integument, in surface view, are polygonal in outline and have straight walls in early stages (Fig. 1J).

Endosperm and embryo. The endosperm development is Nuclear type. The primary endosperm nucleus undergoes free nuclear divisions and in the beginning most of the nuclei are confined towards the micropylar side. Wall formation

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begins from this end and by the time embryo reaches globular stage, the endosperm cells completely fill the embryosac (Fig. 1D). The outermost layer of the endosperm differentiates as a prominent layer and its cells are densely cytoplasmic (Fig. 1G, M). The other cells of the endosperm are large and highly vacuolated. During the course of development almost all the endosperm is consumed except the outermost layer which persists in the mature seed (Fig. 1P). In many developing seeds it is seen that endosperm collapses immediately after globular embryo stage resulting in collapse of the embryo also.

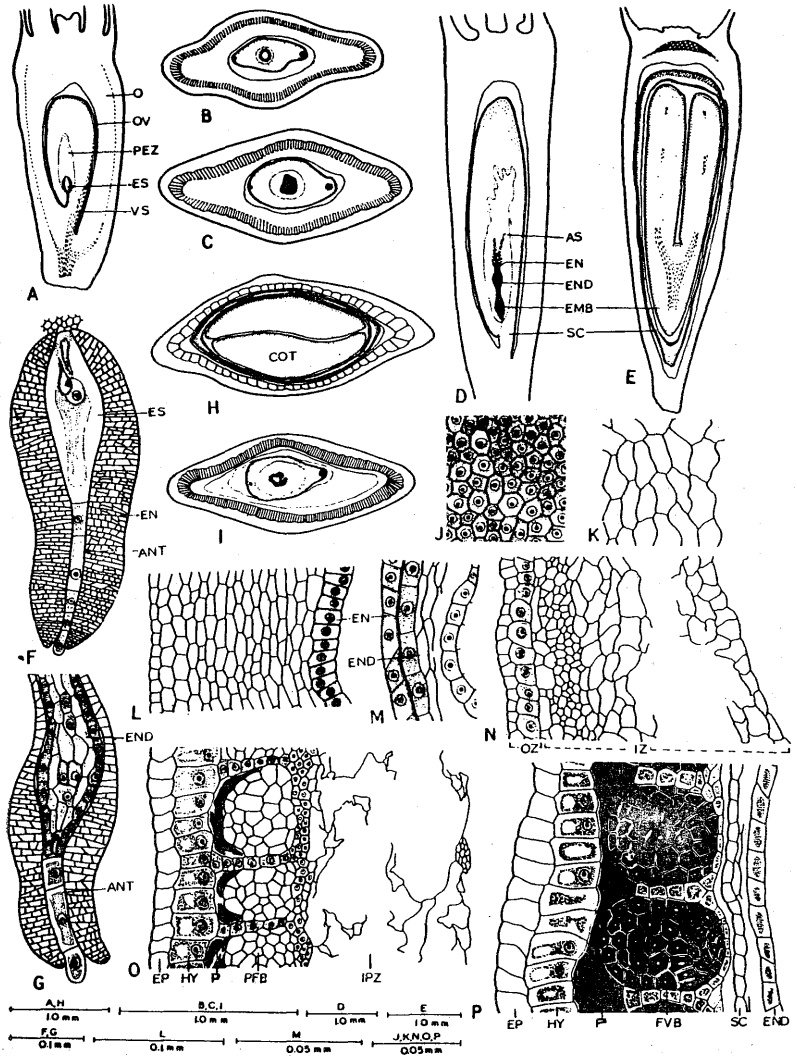
Mature embryos are observed only in less number of seeds. A large number of mature fruits were dissected out and majority of the seeds showed globular embryo stage. The fully developed embryo occupies nearly entire length of the seed (Fig. 1E). It is distinguishable into a hypocotyl-root-axis, two cotyledons, a flat shoot apex and two leaf primordia. Mature embryos are 3.70 mm long, hypocotyl-root-axis being 1.30 mm and cotyledons 2.40 mm.

Seed coat. After fertilization, the cells of the periendothelial zone begin to disorganise and by the time embryo reaches globular stage, an air space appears around the endothelium (Fig. 1C, D). The disorganization of the integumentary cells extends further into the chalazal region also. The cells of the endothelium lying towards the antipodal side divide anti- and peri-clinally making it multilayered (Fig. 1G). At other places the endothelium remains single layered. The cells of the endothelium show a higher degree of cutinization.

In the seeds where endosperm and embryo collapse, the seed coat is thicker (Fig. 1I) but in cases where a fully mature embryo is found, it is 1 to 2-layered (Fig. 1P). In surface view, the outer epidermal cells of the seed coat show wavy outline (Fig. 1K). In mature seeds, the endothelium is seen as a cuticular layer closely adpressed to the persisting layer of the endosperm (Fig. 1P). In cases of failure of fertilization, the cells of the endothelium divide anti- and peri-clinally making the endothelium many layered around the embryo sac (Fig. 1F). The endothelium in such cases, are highly cutinised and appears light brown. Ultimately the endothelium collapses along with the embryo sac resulting in the abortion of the ovule.

Ovary wall and pericarp. The ovary is nearly elliptical in outline as seen in cross-section at various stages of fruit development (Fig. 1B, C, H, I). The ovary wall is differentiated into two zones, outer and inner. The outer zone comprises epidermis and hypodermis while the inner zone is again distinguishable

into two regions. The outer region comprises compactly arranged cells and this constitutes the profibrous zone. The inner region is made up of large parenchymatous cells and some of its cells disorganise to form an air space (Fig. 1N). In between the outer and inner zone schizogenous spaces are seen which



are connected by the strands of uniseriately arranged cells (Fig. 1N). Like the cells of the hypodermis, the cells composing these radial plates also accumulate dense cytoplasm and show prominent nuclei. These together form the proglandular region throughout the periphery of the ovary wall.

As the fruit grows, the proglandular tissue acquires glandular activity and starts exuding phytomelanin into the schizogenous space. By the time embryo reaches globular stage, a good amount of phytomelanin is collected (Fig. 1O). The cells of the profibrous zone at this stage begin to become thick-walled (Fig. 2A, B).

The mature pericarp is differentiated into following zones, (a) a layer of epidermis, (b) a layer of radially elongated hypodermal cells, (c) phytomelanin zone, (d) fibrous strands and (e) a layer of parenchymatous cells. The narrow parenchymatous plate is also distinguishable between the fibrous strands (Fig. 1P).

Fruit. The fruit is quadrangular in outline and black in colour. The fruit body is narrow towards base and broad on the stylar side (Fig. 2D). Pappus is in the form of a ring present at the top of the fruit and the pappus ring has two pointed horn-like structures (Fig. 2C, D). Mature cypselae vary in length from 9-10 mm and 2-2.5 mm in breadth.

Discussion Development of pericarp in *T. diversifolia* is characterised by differentiation of ovary wall into two zones, schizogenous splitting of ovary wall after fertilization and deposition of phytomelanin in the schizogenous space, a feature characteristic of all Heliantheae (Pandey 1976, 1989; Pandey & Singh 1982, Pandey & Kumari 1987; Pandey *et al.* 1986 a, b). Similar pattern of pericarp differentiation has also been observed in members of tribe Eupatorieae (Pandey & Singh 1983, Pandey *et al.* in press). Mature pericarp in *T.*

Fig. 1. *Tithonia diversifolia*. A, B. Longitudinal section and cross section of ovary and ovule at organised female gametophyte stage respectively. C, D. Cross section and longitudinal section of the same at globular embryo stage. E. Longitudinal section of mature cypsela. F. Longitudinal section of part of ovule showing multilayered endothelium. G. Logitudinal section of part of ovule at globular embryo stage. H. Cross section of mature cypsela. I. Cross section of ovary and ovule showing degeneration. J. Epidermal cells of integument in surface view. K. Epidermal cells of seed coat in surface view. L. Longitudinal section of part of integument at organised female gametophyte stage. M. Longitudinal section of part of ovule at globular embryo stage. N. Cross section of part of ovary at organised female gametophyte stage. O. Cross section of part of pericarp at about half mature embryo stage. P. Cross section of part of mature cypsela. (ANT: antipodals, AS: air space, COT. cotyledons, EMB: embryo, EN: endothelium, END: endosperm, EP: epidermis, ES: embryosac, FVB: fibrovascular bundle, HY: hypodermis, IPZ: inner parenchymatous zone, OZ: outer zone, P: phytomelanin layer, PEZ: periendothelial zone, PFB: profibre bundle, SC: seed coat. VS: vascular supply).

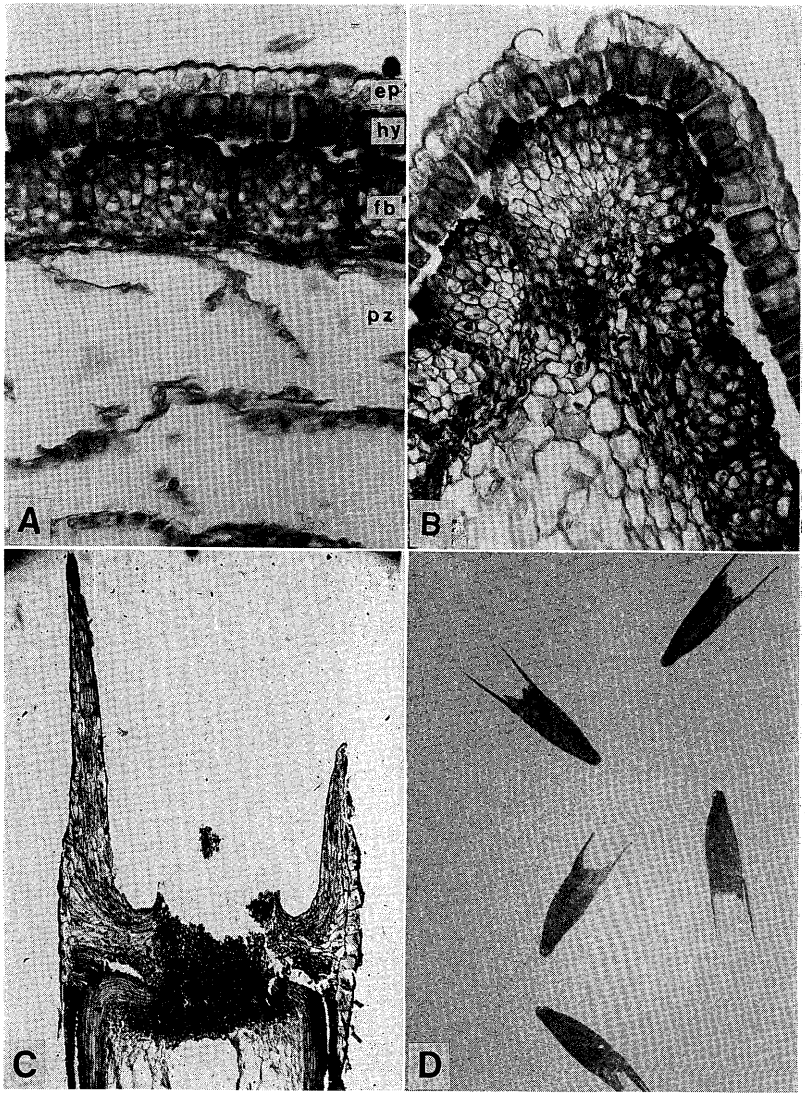


Fig. 2. *Tithonia diversifolia*. A, B. Cross section of part of pericarp at nearly half mature embryo stage ×330. C. Longitudinal section of part of mature cypsela showing two horn-like structure ×170. D. Mature cypsela ×2 (ep: epidermis, fb: fibre bundle, hy: hypodermis, pz: parenchymatous zone).

diversifolia shows fibre bundles (present study), a feature also observed in *T. rotundifolia* and *T. speciosa* (Pandey, unpublished). On the other hand, majority of the Heliantheae show continuous fibre zone (Pandey 1976, 1989; Pandey & Kumari 1987). Presence or absence of fibre bundles in the pericarp may be of systematic significance if more taxa of Heliantheae are studied from this point of view.

In *T. diversifolia* only a single layer of seed coat persists in the mature seeds. The cells of the seed coat do not show any special feature. In *T. rotundifolia* and *T. speciosa*, however, epidermal cells of the seed coat show bulging of the inner tangential walls, a feature also reported in *Xanthium strumarium* (Chopra 1968), *Tagetes erecta* and *T. patula* (Pandey *et al.* 1986b).

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ニトベギクの種子と果皮の形成を報告する。子房壁は成長するにつれて中央に分裂面が入り，そこに phytomelanin が沈積して内外 2 層に分かれる。外側の層は epidermis と hypodermis に分化する。内層は繊維束とそれを取り巻く柔組織層に分化する。ニトベギクの属するヒマワリ連では phytomelanin が沈積する裂け目ができるが，これは他にヒヨドリバナ連に見られる性質である。繊維束が分化することが系統的にどのような意味があるかは今後の問題である。

□ Sze, Philip: **A biology of the algae** i-ix+251 pp. 1986. Wm. C. Brown Publ., Dubuque, Iowa, U. S. A. ¥ ca. 4,500. 著者は序言でこの本の性格を次のように述べている。学生達は生物学について基礎知識をもっているが，藻類については殆ど知識がなく，また扱った経験もないように思われる。そこで最新の研究成果を逐一盛り込んで詳述するのではなく，藻類について広い知識を学生に与えるための初心者向の藻学の入門書として本書を作った。本文は次の 9 章から成る。1．藻類の特徴と多様性，2．藍藻類と原核緑藻プロクロロン，3．緑藻植物門（プラシノ藻綱，緑藻綱，車軸藻綱），4．黄金色藻植物門（黄金色藻綱，プリムネシウム藻綱，黄緑藻綱，真眼点藻綱，ラフィド藻綱，珪藻綱，褐藻綱），5．種々の鞭毛藻類（炎藻植物門，クリプト藻植物門，ユウグレナ植物門），6．紅藻植物門，7．植物プランクトン，8．淡水の附着性藻と気生藻，9．海産の附着性藻。最後に用語解説（7 頁）と 250 余編の文献及び 9 頁に亘る索引がある。上記の 2～6 章は分類を扱い，7～9 章は生態が中心である。各章の終りには更に知識を得たい人のために “Further Reading” の項が設けられ，数編の最新の主要な論文名が掲載されている。（千原光雄）

□ Shrestha, B. P.: **Forest plants of Nepal** 216 pp. 1989. Educational Enterprise, Kathmandu. ¥7,000. ネパールの森林を forestry の立場から概説したもの。冒頭に森林庁の略史が記されているが，これによるとネパールの森林行政はせいぜい50年前からで，組織的には1950年代からはじまったものである。地域ごとおよび森林型ごとに簡単な記述がされており，とくに見るべきものはないが，ネパール全体をカバーしている。樹種によってはローカルな用途が記されていて，参考になる部分もある。巻末に学名，ネパール名，用途などのリストがある。（金井弘夫）